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RENT SHARING TO CONTROL NON-CARTEL SUPPLY IN THE GERMAN CEMENT MARKET¹

Joseph E. Harrington, Jr.[#], Kai Hüschelrath^{*}, and Ulrich Laitenberger[°]

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Abstract

A challenge for many cartels is avoiding a destabilizing increase in non-cartel supply in response to having raised price. In the case of the German cement cartel that operated over 1991-2002, the primary source of non-cartel supply was imports from Eastern European cement manufacturers. Industry sources have claimed that the cartel sought to control imports by sharing rents with intermediaries in order to discourage them from sourcing foreign supply. Specifically, cartel members would allow an intermediary to issue the invoice for a transaction and charge a fee even though the output went directly from the cartel member's plant to the customer. We investigate this claim by first developing a theory of collusive pricing that takes account of the option of bribing intermediaries. The theory predicts that the cement cartel members are more likely to share rents with an intermediary when the nearest Eastern European plant is closer and there is more Eastern European capacity outside of the control of the cartel. Estimating a logit model that predicts when a cartel member sells through an intermediary, the empirical analysis supports both predictions.

Keywords Collusion, cartel, non-cartel supply, cement, distribution channels, intermediary

JEL Class L41, K21

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1. Introduction

Collusion is not easy. The prospect of reaping large profits from raising the market price can be jeopardized by several sources of instability. First, there is internal instability coming from a member violating the collusive agreement. This act of non-compliance is typically for the purpose of gaining a larger share of the market than had been allocated to it. Second, there is external instability in the form of alternative sources of supply. When the cartel raises price and the cartel is not all-inclusive, those firms outside of the cartel will often seek to increase their sales by undercutting the collusive price. And, even when all existing suppliers are members of the cartel, a higher market price can attract entry. Third, a cartel must avoid detection by customers and the competition authority which would bring an end to collusion. In sum, effective collusion requires that cartel members are sufficiently compliant with the collusive agreement, non-cartel members do not significantly expand supply, and the cartel avoids detection.²

Let us consider the second source of cartel instability: increased supply by firms that reside outside of the cartel. There are numerous episodes for which an expansion in non-cartel supply either greatly impacted the profitability of collusion or even resulted in the demise of the cartel. A notable example is the vitamin C cartel of the early 1990s.³ Formed in 1991, it comprised the four largest producers who in aggregate had 87 percent of global sales. Of particular relevance, the cartel excluded Chinese manufacturers who had a market share of 8 percent at the time. The cartel implemented a 30 percent increase in prices from 1990 to late 1993, in response to which it lost 29 percent of global sales to Chinese suppliers, who tripled their sales, and other fringe producers. With the erosion of the cartel's share of the global market, prices subsequently fell by 33 percent from the end of 1993 to 1995. The cartel's last formal meeting occurred in August 1995. The failure to control the growth of non-cartel supply resulted in cartel death.

Cartels are well aware of the threat of non-cartel supply and they have deployed four general methods for handling it, which we refer to as takeover, starvation, coercion, and bribery. The *takeover* approach is the most straightforward and probably the most effective

² For some cases and empirical analyses concerning these various sources of instability, the reader is referred to Harrington (2006), Levenstein and Suslow (2006, 2011), Connor (2008), and Marshall and Marx (2012).

³ The details are from Connor (2008).

(though not necessarily the most profitable). Here, the cartel takes control of the sources of non-cartel supply by acquiring non-cartel suppliers or the assets necessary to produce. A *starvation* strategy curtails non-cartel supply by taking control of an essential input or technology. *Coercion* refers to aggressive practices – such as a targeted price war - that harms non-cartel suppliers with the intent of either inducing them to constrain their supply or join the cartel or exit the market. Rather than use the stick, a *bribery* strategy uses the carrot by sharing collusive rents with non-cartel suppliers if they agree to limit their expansion of supply. As the identification of these four strategies is, to our knowledge, new to the literature, Section 2 illustrates them with a collection of cartel cases.

The focus of this paper is exploring how non-cartel supply was handled in the case of the German cement cartel which lasted from 1991 to 2002. The primary threat was imports from cement manufacturers in Eastern Europe, specifically, plants located in the Czech Republic, Poland, and Slovakia. For legal and logistical reasons, importation from those countries into Germany required the use of German companies acting as intermediaries. The claim has been made in the context of a private litigation case that, in order to avoid intermediaries bringing the cement of Eastern European suppliers into the German market, the German cement cartel shared some of the collusive rents with those intermediaries. In light of the four methods for handling non-cartel supply, this conjectured strategy could be cast as either starvation - by controlling a key input to foreign cement manufacturers - or bribery - in that intermediaries were bought off.

For the purpose of examining the validity of the claim that the German cement cartel bribed intermediaries in order to limit non-cartel supply, this paper develops a theory of collusive behavior that encompasses the option of sharing rents with intermediaries. The theory is then taken to data and we find evidence in support of the theory's predictions. Hence, we find empirical support for the claim that the German cement cartel bought off intermediaries for the purpose of limiting imports and thereby constraining sources of non-cartel supply.

The paper is organized as follows. Section 2 reviews how various cartels have controlled non-cartel supply. Section 3 provides a general description of the German cement cartel including an overview of primary threats to its stability with a focus on the role of intermediaries. In Section 4, a theory of collusive pricing in the presence of intermediaries and non-cartel suppliers is developed which allows for the option of sharing rents with an

intermediary in exchange for them not sourcing non-cartel supply. That theory generates a set of hypotheses that are then tested in Section 5. Section 6 concludes.

2. Cartel Strategies for Controlling Non-Cartel Supply

Suppose a cartel increases price in the presence of some suppliers who are not part of the cartel. The likely response of those non-cartel suppliers is to undercut the cartel's price and expand supply which has the potential for substantively undermining the profitability of collusion. In responding to the expansion of non-cartel supply, cartels have pursued four strategies: takeover, starvation, coercion, and bribery. Examples of each of these are provided below.

Takeover: A cartel curtails non-cartel supply by acquiring the non-cartel suppliers or the assets used to provide that supply.

The five global producers of aluminum formed a cartel in 1900-01 which lasted until 1908 when a recession and entry caused the cartel's collapse. The established firms then went about acquiring nine recent entrants after which they re-established the cartel in 1912.⁴

Members of the international steel cartel in the 1930s acquired fringe firms at prices based on "their nuisance value to the cartel" which apparently exceeded a valuation based on their projected earnings.⁵

The electrical and mechanical carbon and graphite products cartel operated over 1988-99 and struggled with non-cartel suppliers known as "cutters" which would purchase carbon blocks from the cartel members and then produce final products that would compete with the cartel's supply. One cutter in particular, EKL, was aggressively supplying the German market to the point that the cartel discussed a coordinated response and entertained two options. First, none of the members of the cartel would supply any graphite to EKL (a strategy defined below to be "starvation"). Second, EKL would be denied any market share by cartel members systematically undercutting EKL's price with respect to those customers entertaining doing

⁴ See Storli (2014)

⁵ Stocking and Watkins (1946), p. 177.

business with EKL (a strategy defined below to be “coercion”). Ultimately, the takeover approach was pursued as cartel member SGL Carbon acquired EKL in 1997.⁶

Starvation: A cartel curtails non-cartel supply by limiting non-cartel suppliers’ access to an essential input or technology.

The Austria-Hungary sugar cartel was formed in 1891 to coordinate the supply of refined sugar. By the time of its demise in 1894, the cartel had learned the importance of controlling raw sugar to constrain the non-cartel supply of refined sugar. Reformed in 1897, the 58 sugar refiners in the cartel put together an exclusive arrangement whereby the 178 raw sugar suppliers would only supply the 58 cartel members and the latter would only buy raw sugar from those suppliers.⁷

From the late 1980s into the 1990s, the international sorbates cartel struggled with entry by Russian and Chinese suppliers. When several potential competitors from China requested licensing the sorbates technology from existing producers, the five cartel members agreed not to provide their technology to other sorbates producers.⁸

Coercion: A cartel curtails non-cartel supply through aggressive practices, such as selective price cuts with respect to a non-cartel supplier’s customers, with either the intent of continuing these practices until the non-cartel supplier constrains its supply or joins the cartel or exits the market.

The Swedish beer brewing industry formed a national cartel in 1906 that lasted for fifty years. The cartel’s primary initial task was recruiting members and, by late 1908, only a few minor breweries had not joined. The methods of recruitment were initially persuasion but, if that failed, then coercion. In a particularly difficult case in the city of Eskilstuna, the cartel leased a small brewery and used it to engage in intense price competition against a recalcitrant firm which eventually chose to join the cartel.⁹

⁶ *Official Journal of the European Union*, L 125/45, 28.4.2004, Case No. C.38.359 - Electrical and mechanical carbon and graphite products, Decision of December 3, 2003; cited in Harrington (2006)

⁷ See Fink (2016).

⁸ Commission of the European Communities, Commission Decision of 1.10.2003 (Case COMP/E-1/37.370 - Sorbates); cited in Harrington (2006).

⁹ See Lundqvist (1998).

In the early 20th century, shipping cartels (referred to as “conferences”) were found to have “successfully conspired to drive competitors from the market or coerce them to join the conferences, through the use of ‘fighting ships’ that systematically undercut competitors’ rates for however long it took to drive them out of the business.”¹⁰

The international electrical equipment cartel of the 1930s created a “deposit fund” which “could be used to support cut-throat competition against a non-member competitor in any of the territory [sic] coming within the scope of operation of the agreement” or “to support competitive warfare against [a] former cartel member.”¹¹

Formed in 1929, the international steel rail cartel sought to constrain supply from non-cartel members “by allowing the London Committee to fix, when apprised of such threatened competition, a sufficiently lower price ... to make sure the nonassociated producer would not obtain the order and to compensate the [cartel member] for the differential between this lower price and the standard price by payment out of a reserve fund provided by contributions on a tonnage-delivered basis by [cartel members].”¹²

In the district heating pipes cartel of the 1990s, the Swedish firm Powerpipe declined an invitation to join the cartel and later filed a complaint with the European Commission on the grounds that the colluding firms had acted anti-competitively against it. Cartel members had recruited key employees of Powerpipe and led Powerpipe to understand that it should withdraw from the German market. After Powerpipe was awarded a sizable German contract, the cartel decided to organize a collective boycott of Powerpipe's customers and suppliers.¹³

With the vitamin B1 cartel, increased non-cartel supply by Chinese manufacturers led cartel members to price aggressively in a selective manner to reclaim lost customers.¹⁴

Bribery: A cartel curtails non-cartel supply by sharing collusive rents with non-cartel suppliers.

¹⁰ Marshall and Marx (2012), p. 148, f. 7.

¹¹ FTC “Report on International Electrical Equipment Cartels” (1948), p. 33.

¹² FTC “Report on International Steel Cartels” (1948), p. 4.

¹³ Judgment of the Court of First Instance (Fourth Chamber) of 20 March 2002. - ABB Asea Brown Boveri Ltd v Commission of the European Communities; cited in Harrington (2006).

¹⁴ *Official Journal of the European Union*, L 6/1, 10.1.2003, Case COMP/E-1/37.512 - Vitamins, Decision of November 21, 2001; cited in Harrington (2006).

From 1885 to 1902, competition in the bromine industry was controlled by a pool comprising twelve producers. The pool was a legal entity with exclusive contracts to buy the output of a bromine producer at a guaranteed price. Deutsche Bromkonvention represented the only source of foreign non-cartel supply and the pool controlled it by entering an agreement whereby the pool would not export in exchange for Deutsche Bromkonvention not supplying the U.S. market.¹⁵

In the global alkali cartel of the 1920s, cartel members ICI and Alkasso were concerned with the entry of a Brazilian company, Matarazzo. To forestall such entry, they agreed to sell alkali at preferential prices to Matarazzo.¹⁶

The vitamin B2 cartel managed non-cartel supply by having cartel members purchase it. In order to control Coors, which was a producer of B2 but not a member of the cartel, cartel members Roche and BASF agreed that Roche would purchase 115 tons of B2 (which represented half of Coors's capacity) and BASF in turn would purchase 43 tons from Roche. In this manner, they shared the burden of controlling Coors' supply.¹⁷

3. The German Cement Cartel and the Threat of Imports

3.1 Primary Threats to Cartel Stability

Since 1991, a cement cartel existed in Germany among the six largest cement companies: Dyckerhoff AG, HeidelbergCement AG, Lafarge Zement GmbH, Readymix AG, Schwenk Zement KG, and Holcim (Deutschland) AG. These companies divided up the German cement market by setting up regional cartels in the north, south, east, and west. For those companies with plants located in different parts of the country, they were members of multiple regional cartels. Collusion was implemented through a market-sharing agreement that set sales quotas for members of each regional cartel. In addition, the cartel sought to include or acquire small and medium-sized domestic firms.¹⁸

¹⁵ See Levenstein (1997).

¹⁶ See Stocking and Watkins (1946).

¹⁷ *Official Journal of the European Union*, L 6/1, 10.1.2003, Case COMP/E-1/37.512 - Vitamins, Decision of November 21, 2001; cited in Harrington (2006).

¹⁸ For further details on the German cement cartel, the reader is referred to Friederiszick and Röller (2010), Hüschelrath and Veith (2016), and Harrington, Hüschelrath, Laitenberger, and Smuda (2015).

The cartel lasted from 1991 to 2002 and during that time there were two major developments that challenged the stability of the cartel. First, as analyzed in Harrington Hüsichelrath, Laitenberger, and Smuda (2015), demand for cement from construction activities in East Germany fell significantly below expectations. The resulting underutilization of production capacities induced one of the cartel members to deviate from the collusive agreement which ultimately led to the breakdown of the cartel in February 2002. A second source of instability arose in the early days of the cement cartel. The political liberalization processes in most Eastern European countries – including their transition to market economies – opened up the possibility of low-priced imports into Germany from cement manufacturers in countries such as the Czech Republic, Poland, and Slovakia.¹⁹ These alternative sources of cement supply for German customers presented a possibly serious challenge to the cement cartel.²⁰

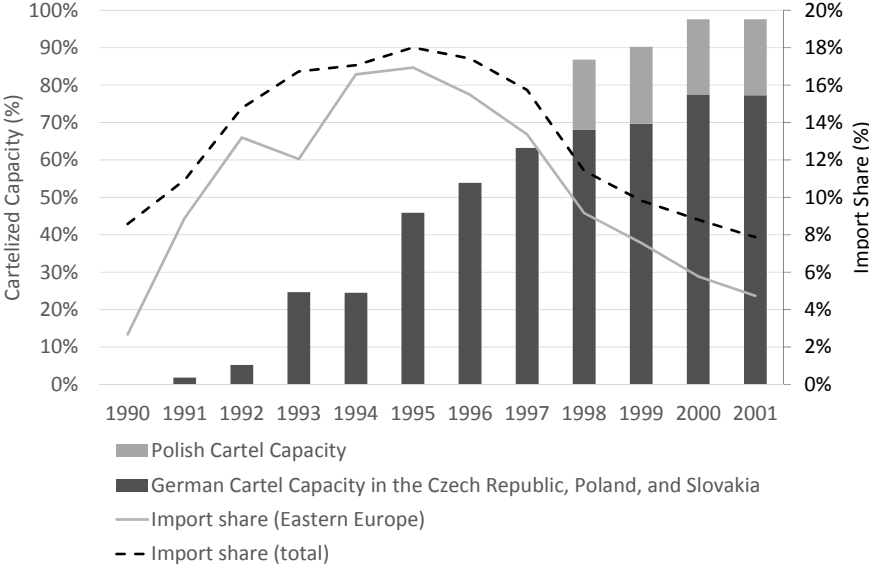


Figure 1: Import Shares for Eastern Europe and Cartelized Capacity in the Czech Republic, Poland, and Slovakia, 1991-2001

Data Sources: Verein Deutscher Zementwerke e.V.; German Statistical Office; World Cement Directory; Polish cartel decision document; own ownership database²¹

¹⁹ According to Fiederer et al. (1994, pp. 61 ff.), the average domestic price for a ton of cement in 1993 was about EUR 75 (including transportation costs) compared to an import price which, before adding transportation costs, was around EUR 40 per ton for Czech cement. As discussed by Fiederer et al. (1994), the main sources of the lower prices were the lower labor and energy costs of Eastern European firms.

²⁰ Fiederer et al. (1994) offers a detailed assessment of the German cement market. For a theoretical investigation of the threat of imports for cartel stability, see Feinberg (1989).

²¹ The cartelized capacity share is calculated by using the kiln capacities as reported in the World Cement Directories 1991, 1996 and 2002. All values for 1998 were missing and were interpolated. Additionally, for

The significance of the import threat from Eastern Europe as well as some indication of how the cartel responded to that threat is documented in Figure 1. Reading off of the right vertical axis, the dashed line is the share of German cement consumption (in volume) supplied by plants not located in Germany, while the solid line is the share of consumption supplied by plants located in Eastern Europe. The black bars report the fraction of capacity in the Czech Republic, Poland, and Slovakia owned by members of the German cement cartel (reading off of the left vertical axis). As the Czech Republic, Poland, and Slovakia were the overwhelming suppliers to Germany from Eastern Europe (with no less than 93 percent of annual Eastern European imports to Germany during our observation period), we will refer to capacity and imports from those three countries as Eastern European capacity and imports. Finally, let us note that the import shares are based on sales from all plants in the Czech Republic, Poland, and Slovakia including those owned by members of the German cement cartel.²² However, we will argue that the evidence is consistent with the cartel not exporting much cement from their Eastern European plants to Germany so that the import shares reported in Figure 1 can be viewed as largely coming from non-cartel suppliers.

As seen in Figure 1, the early years of the cartel experienced a substantial increase in the amount of cement imported from Eastern Europe. While only 3 percent of German cement consumption was supplied by those foreign plants in 1990, it had climbed to 13 percent by 1992. (Note that the German cement cartel controlled only 20 percent of Eastern European capacity in 1992 so it is unlikely that the rise can be attributed to imports produced by capacity controlled by the cartel.) The import share peaked in 1995 at almost 17 percent of German demand and then began a steady decline throughout the remaining period. By 2001, the import share was back to its 1990 level of around 4 percent.²³ (Note that this declining

Slovakia, data for plant Stupava and for the year 1997 were missing. For the Czech Republic, data for plant Hranice in the years 1995-1997 and for plant Prachovice in the year 2002 were missing. For Poland, data for plant Gorka and for plant Strzelce in the years 1999 to 2002 were missing. The respective missing values were interpolated with either the respective last year available or the average between the respective years. Capacity values for the years after 2002 were taken from 2001 and set to zero in case of plant closures.

²² The available import-export statistics do not allow disaggregating it into sales from plants owned by German companies and by non-German companies.

²³ While there were imports from plants in Western European countries, their import share (relative to German consumption) fluctuated in a fairly tight range of 4 to 7 percent in our observation period. Imports from those countries as well as other Eastern European countries were small in size and were mostly observed if the respective customer was close to the German border. As discussed by Friederiszick and Röller (2001, p. 66ff.), such imports have always existed in the German cement market and are typically aimed at reducing transport costs. The absolute level of these imports is moderate in size and prices are typically similar to the

import share was occurring while the share of Eastern European capacity controlled by the German cement cartel was rising. Again, this is evidence that they were choosing not to import cement from those plants to the German market and, therefore, the import share largely represents supply from Eastern European plants not controlled by the cartel.)

It is reasonable to attribute the sizable increase in the import share over 1990-95 to the higher prices for cement in Germany as a result of the cartel. The high domestic prices provided an opening for Eastern European cement manufacturers to sell their product at prices which would more than cover their production and transportation costs. However, the German cement cartel was not idly standing by while non-cartel suppliers captured an increasing share of the market. Beginning in 1991, members of the German cement cartel acquired plants in the Czech Republic, Poland and Slovakia and either closed the plant or curtailed exports to Germany. From 1991 to 2001, the six largest German cement companies bought 20 cement plants in Poland, seven in the Czech Republic, and five in Slovakia.²⁴ These acquisitions led to a substantial rise in the share of Eastern European production capacity controlled by the German cement cartel as seen in Figure 1 (black bars). In addition, starting in 1998, there was a cartel in the Polish cement market among Polish cement manufacturers, and there is evidence of a mutual understanding between them and the German cement cartel to stay out of each other's market.²⁵ For this reason, Figure 1 also reports the fraction of Eastern European capacity controlled by the German *and* Polish cement cartels (black and gray bars) on the grounds that all of that capacity may have been excluded as a source of non-cartel supply into the German cement market.²⁶

From 1990 to 1999, the German cement cartel went from having no production capacity in Eastern Europe to controlling 77 percent of capacity and perhaps as much as 98 percent (if one includes the Polish cement cartel's capacity). Thus, in response to the rising flow of imports from non-cartel suppliers over 1991-95, the cartel managed to cut off that supply - as

German level. They add that these imports tend to decrease with a rise in demand in the respective foreign country.

²⁴ A list of these acquisitions is available from the authors upon request.

²⁵ In the Polish Cartel, there is evidence that the quota of Miebach was increased as compensation for their decreased export activities to Germany (paragraph 171 and 479, Polish cartel decision).

²⁶ For details on the Polish cement cartel, the reader is referred to Bejger (2011).

reflected in a decline in the import share from 17 percent in 1995 to 4 percent in 2001 - by taking control of many of the plants in the Czech Republic, Poland and Slovakia.

3.2 The Role of Intermediaries in the Supply of Imports

In the German cement market, a customer could purchase cement directly from a cement manufacturer or through an intermediary. The former is referred to as “direct selling” and involves a direct negotiation between the buyer and the cement producer. After a purchase agreement is reached, the product is delivered by the seller or picked up by either the buyer or a commissioned third party (typically, a shipper). The invoice is directly issued by the seller who is the cement producer. When instead an intermediary is used, a customer places an order through that intermediary. The role of the intermediary is issuing the invoice and covering the delcredere risk (that is, the possible loss from a party not fulfilling its obligations). The intermediary may also handle price negotiations with the cement manufacturer on behalf of the buyer and could be involved in the transportation of cement from the plant to the customer.

There is potentially substantive value in the use of an intermediary when the customer is small or the cement manufacturer’s plant is outside of Germany. With a small customer, an intermediary can be better at sourcing supply and negotiating with a supplier. For legal and logistical reasons, it was difficult for German cement customers to buy directly from Eastern European cement manufacturers and thus they heavily used German intermediaries. For the 36 German customers in our data set over 1993-2005 (details of which are provided in Section 5), Figure 2 breaks down the number of transactions according to whether the transaction was direct or involved an intermediary. Consistent with the essential role of intermediaries when dealing with foreign plants, 91 percent of all transactions between a German customer and a non-German plant (for the entire period) used an intermediary. In contrast, only 66 percent of transactions involved an intermediary when the plant was located in Germany.

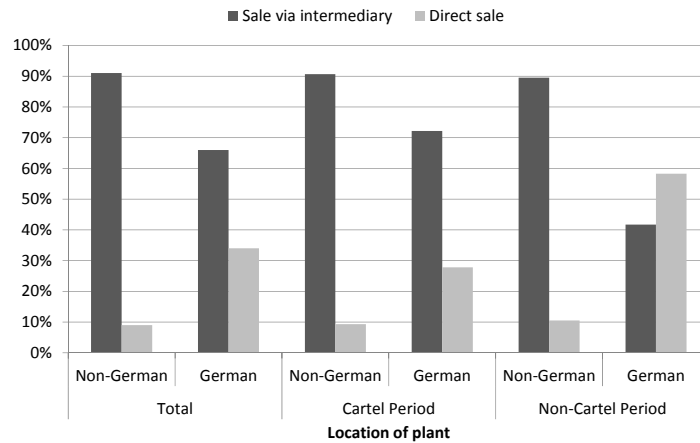


Figure 2: Use of Direct Selling and Intermediaries Depending on Plant Location

Data Source: own analysis based on CDC data

By comparison, the value in using an intermediary is not at all clear when the cement customer is large and the plant is located in Germany:²⁷

In the sale of larger amounts of cement, the functions [of the intermediaries] are very limited. The acquisition of customers including the agreement on a certain price typically does not rest with the intermediary but with the cement producer. The transport from the producer to the customer may, but need not, be carried out by the intermediary.

It is then curious that, during the cartel period, many large customers who were purchasing from German cement manufacturers did so through intermediaries. Figure 3 plots how the annual volume is allocated between the two distribution channels for the 36 customers in our data set. In the early years of the cartel, around 75 percent of volume went through intermediaries and it was more than 50 percent in every year during the entire cartel period. For these customers, who generally handled large volumes, the value provided by an intermediary would seem to be minimal. Even if an intermediary was used, these customers used the same transportation services as with “direct selling” in that the cement went directly from the plant to the customer. One could argue that the intermediary did little more than process an invoice.

²⁷ Translated from Spenner (1996, p. 48)

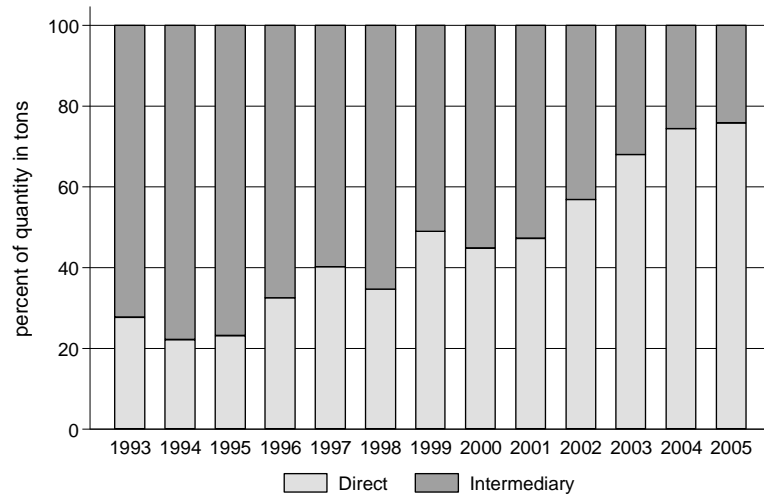


Figure 3: Shares of Different Distribution Channels, 1993-2005

Data Source: own analysis based on CDC data

As a possible explanation of this puzzle, industry sources have claimed in a private litigation case²⁸ that the members of the German cement cartel funneled transactions through intermediaries as a way to share collusive rents in exchange for intermediaries not importing Eastern European cement. As already documented, intermediaries had an essential role in importing supply from Eastern European cement manufacturers. As the claimed argument goes, intermediaries were allowed to invoice transactions between German cement customers and German cartel members for which they charged a fee in exchange for not bringing in imports. In bribing the intermediaries, one can either think of the intermediary as an essential input (for non-cartel cement companies in Eastern Europe) or as a non-cartel supplier. With either interpretation, the practice amounts to sharing rents with non-members of the cartel in order to avoid competition with the cartel.

Figure 2 provides some preliminary evidence in support of this claim. While the use of intermediaries with a non-German plant was basically the same between the cartel and post-cartel periods (around 90 percent of transactions in both cases), intermediaries were significantly less used with German plants after cartel breakdown. During the cartel phase, 72

²⁸ Regional Court of Düsseldorf, Case 34 O (Kart) 147/05 of August 2005. Further general information on civil proceedings concerning the German cement cartel is provided on the following webpage: <http://www.carteldamageclaims.com/portfolios/cement-cartels/> (last accessed on 6 February 2016).

percent of transactions with German plants used an intermediary. But, after the cartel's breakdown, an intermediary was used in only 42 percent of transactions.

While intriguing, this claim is speculative and the evidence is at best suggestive. It is quite possible that intermediaries provided certain functions for large customers that were not easily apparent, and the reduced use of intermediaries in the post-cartel period could be due to a variety of factors associated with a change in the competitive landscape. The objective of this paper is to systematically test the claim that the cartel shared collusive profits with intermediaries in order to limit imports. For this purpose, a collusive theory that endogenizes rent-sharing with an intermediary is developed in Section 3. That theory provides some testable hypotheses for behavior during the cartel period which are then taken to the data in Section 5.

4. A Theory of Collusive Pricing with Intermediaries

Consider a market with a cartel that acts as a joint profit-maximizer and suppose there is a single intermediary and a single non-cartel supplier.²⁹ The cartel and the non-cartel supplier offer homogeneous products and the market demand curve is $D(p)$. The cartel produces at constant marginal cost c' . For the non-cartel firm to supply this market, it must operate through the intermediary. The non-cartel firm produces at constant marginal cost c'' , while the intermediary's services are provided at constant marginal cost g . Assume $c'' + g > c'$ – so the cartel is the more efficient supplier – and $D(c'' + g) > 0$ – so it is feasible for the non-cartel firm to price above cost and have positive demand.

Assume the demand curve is such that $(p - c)D(p)$ is strictly quasi-concave (when positive) and, therefore, the monopoly price $p^m(c) = \operatorname{argmax} (p - c)D(p)$ exists. It is also supposed that $p^m(c)$ is increasing in c so, in particular, $p^m(c'' + g) > p^m(c')$. Finally, assume that the cost differential between the cartel and the non-cartel supplier is not too large so that: $p^m(c') > c'' + g$.

²⁹ For simplicity, we will specify a one-shot setting and assume a joint profit-maximizing cartel. However, all results can be derived as an equilibrium in an infinitely repeated game in which each firm maximizes the present value of its profit stream and firms' discount factors are sufficiently close to one. It is also assumed for simplicity that there is one intermediary and one non-cartel supplier. While we believe the resulting insight is robust to that assumption, extending the analysis to multiple intermediaries and multiple non-cartel suppliers would be a major complication as it would involve modelling multi-lateral bargaining.

A standard approach to analyzing this setting is to suppose that the cartel chooses a price to maximize its joint profit while taking into account how the non-cartel supplier will respond; that is, the extensive form is sequential move with the cartel acting as a price leader. In this case, if the cartel's price exceeds the cost of non-cartel supply then the partnership of the non-cartel firm and intermediary will price below it and leave the cartel with zero demand and zero profit. To avoid that outcome, the cartel will price just below $c'' + g$ in response to which the non-cartel firm prices at (or above) $c'' + g$. The cartel earns profit of approximately $(c'' + g - c')D(c'' + g)$. As long as the cost advantage of the cartel is not too great – so that $p^m(c') > c'' + g$ – the cartel is constrained to pricing no higher than the cost of alternative supply.³⁰

Let us now enrich this setting by giving the cartel the opportunity to share rents with the intermediary for the purpose of preventing non-cartel supply from entering the market. With three players, there are a variety of possible extensive forms though we will argue for a particular one. As assumed above, the cartel commits to price and then those firms that are not part of the cartel select a price; thus, the cartel acts as a price leader.

Having set its price, the cartel is presumed to approach the intermediary about a possible sharing of profit if, in exchange, the intermediary does not offer its services to the non-cartel supplier. Rather than explicitly model the bargaining process between the cartel and the intermediary, we will take a reduced form approach by assuming that a per unit payment from the cartel to the intermediary is determined by the generalized Nash Bargaining Solution (NBS). If the two parties succeed in coming to an agreement then the game ends as the intermediary does not provide its services to the non-cartel firm and, as a result, there is no non-cartel supply. If the cartel and intermediary fail to come to an agreement, the non-cartel firm and the intermediary bargain over both the price to the consumer and how revenues are shared between the two parties. Again, the outcome of that negotiation is represented as a generalized NBS. If they fail to come to an agreement then there is no non-cartel supply and the cartel sells to the market at the price it set in the first stage. This sequence of moves is depicted in Figure 4.

³⁰ The sequential-move extensive form is used, for example, in Bos and Harrington (2010). If instead the two suppliers make simultaneous price decisions then there are many other Nash equilibria including the just described subgame perfect equilibrium for this sequential-move game. The latter outcome is generally thought to be the most reasonable Nash equilibrium for the simultaneous-move game.

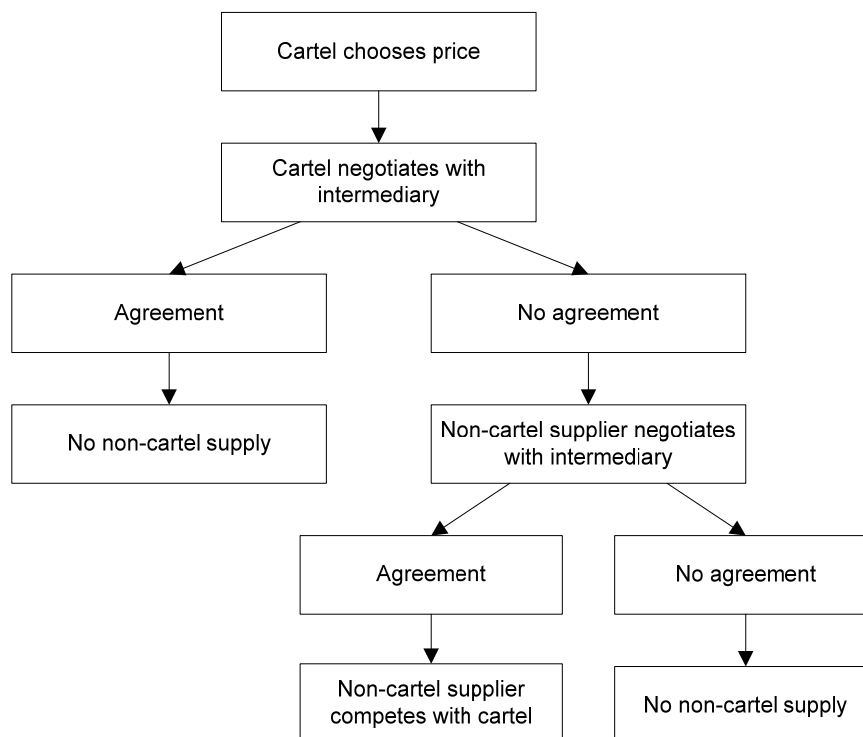


Figure 4: Sequence of Moves in Cartel-Intermediary-Non-Cartel Supplier Game

Note that we are assuming that the intermediary and the non-cartel firm bargain over both the product price and a sharing of revenues with the intermediary, while the intermediary and the cartel only bargain over the sharing of revenues as the cartel has already chosen its price. This asymmetric treatment is justified because the cartel can sell without the assistance of the intermediary, while the non-cartel firm cannot. Thus, the cartel can commit to a price and then approach the intermediary about making a deal. In contrast, the non-cartel firm and intermediary are both necessary for supplying the market so it is not meaningful for the non-cartel firm to have set the product price without having come to an agreement with the intermediary.

In sum, the game has three stages: 1) the cartel sets a price p^c at which it is willing to sell to customers; 2) the cartel and the intermediary negotiate over a per unit payment paid to the intermediary which represents a splitting of profit associated with the cartel selling at a price p^c ; and 3) if the cartel and the intermediary fail to reach an agreement then the intermediary and the non-cartel supplier bargain over the product price and how that revenue is allocated between the two parties. The presumption is that if the cartel fails to come to an agreement with the intermediary in stage 2 then the intermediary will cut a deal with the non-cartel supplier.

This three-stage game is solved using backward induction. Suppose bargaining between the cartel and the intermediary broke down so stage 3 is reached. With regards to the bargaining between the intermediary and the non-cartel firm, their threat points have them each earn zero profit because they do not supply the market. The intermediary and non-cartel supplier are assumed to choose the price p (charged to customers) and the payment received per unit by the intermediary. Denoting that per unit payment by r , the non-cartel supplier then receives $p - r$ per unit. Note that the NBS will have $p \in (c'' + g, p^c)$ for that yields positive total profit while any other price yields non-positive profit.

Letting β denote the bargaining power of the non-cartel supplier, p and r are chosen to solve the NBS objective:

$$\begin{aligned} \max_{p,r} [(p - c'' - r)D(p)]^\beta [(r - g)D(p)]^{1-\beta} \\ = \max_{p,r} (p - c'' - r)^\beta (r - g)^{1-\beta} D(p) \end{aligned} \quad (1)$$

Let us first solve for r and then solve for p . The first-order condition with respect to the payment to the intermediary is:

$$(p - c'' - r)^{\beta-1} (r - g)^{-\beta} [-\beta(r - g) + (1 - \beta)(p - c'' - r)] D(p) = 0, \quad (2)$$

which is then solved for r : $r^*(p) = (1 - \beta)(p - c'') + \beta g$. Given customers pay a price p for non-cartel supply, the intermediary earns profit of

$$(r^*(p) - g)D(p) = (1 - \beta)(p - c'' - g)D(p) \quad (3)$$

and the non-cartel supplier receives:

$$(p - c'' - r^*(p))D(p) = \beta(p - c'' - g)D(p). \quad (4)$$

Next let us solve for the optimal price to charge for non-cartel supply. Assuming that the cartel's price is no higher than its monopoly price, it follows from our earlier assumptions that

$$\frac{\partial (p - c'' - g)D(p)}{\partial p} > 0 \quad \text{for all } p < p^c (\leq p^m(c') < p^m(c'' + g)) \quad (5)$$

in which case the payoffs for the intermediary and the non-cartel supplier are maximized by pricing just below p^c . In other words, they set the product price to maximize their total profit $(p - c'' - g)D(p)$ – which requires just undercutting the cartel's price – and then

allocate that profit according to their bargaining power. In conclusion, the stage 3 payoffs to the intermediary and non-cartel supplier are, respectively,

$$(1 - \beta)(p^c - c'' - g)D(p^c) \text{ and } \beta(p^c - c'' - g)D(p^c). \quad (6)$$

Let us now move to stage 2 where the cartel and the intermediary bargain given the cartel has set a product price of p^c . s will denote the per unit payment received by the intermediary in which case the cartel receives $p^c - s$ per unit. Given that the cartel does not need the services of the intermediary, the cost g is not incurred and the payment to the intermediary is only to prevent it from offering its services to the non-cartel supplier.

Letting α denote the bargaining power of the cartel, s is chosen to solve the NBS objective:

$$\max_s [(p^c - c' - s)D(p^c)]^\alpha [sD(p^c) - (1 - \beta)(p^c - c'' - g)D(p^c)]^{1-\alpha}$$

or

$$\max_s (p^c - c' - s)^\alpha [s - (1 - \beta)(p^c - c'' - g)]^{1-\alpha} D(p^c). \quad (7)$$

Note that the threat point for the cartel is zero because failure to agree results in the non-cartel firm (with the assistance of the intermediary) undercutting the cartel's price. In contrast, the intermediary's threat point is $(1 - \beta)(p^c - c'' - g)$ which is its profit from working with the non-cartel firm to undercut the cartel's price and supply the market.

The first-order condition is

$$0 = \{-\alpha(p^c - c' - s)^{\alpha-1}[s - (1 - \beta)(p^c - c'' - g)]^{1-\alpha} + (1 - \alpha)(p^c - c' - s)^\alpha [s - (1 - \beta)(p^c - c'' - g)]^{1-\alpha}\} D(p^c). \quad (8)$$

Solving it for the NBS per unit payment to the intermediary yields

$$s^*(p^c) = (1 - \alpha\beta)p^c - (1 - \alpha)c' - \alpha(1 - \beta)(c'' + g). \quad (9)$$

The intermediary's payment is decreasing in the bargaining power of the cartel and the bargaining power of the non-cartel supplier:

$$\frac{\partial s^*(p^c)}{\partial \alpha} = -(p^c - c') + (1 - \beta)(p^c - c'' - g) < 0 \quad (10a)$$

$$\frac{\partial s^*(p^c)}{\partial \beta} = -\alpha(p^c - c'' - g) < 0. \quad (10b)$$

Because less bargaining power with respect to the non-cartel supplier lowers the stage 3 payoff for the intermediary, its threat point in bargaining with the cartel is smaller which results in a lower payment; hence, $s^*(p^c)$ is decreasing in β . The payoffs to the intermediary and the cartel, respectively, are

$$s^*(p^c)D(p^c) = [(1 - \alpha\beta)p^c - (1 - \alpha)c' - \alpha(1 - \beta)(c'' + g)]D(p^c) \quad (11)$$

$$[p^c - c' - s^*(p^c)]D(p^c) = \alpha[\beta p^c - c' + (1 - \beta)(c'' + g)]D(p^c) \quad (12)$$

Arriving at stage 1, the cartel chooses the product price to maximize its profit taking into account how it will influence its bargaining with the intermediary. If it prices above $c'' + g$ then the cartel will need to come to an agreement with the intermediary as failure would result in the intermediary and the non-cartel supplier undercutting the cartel's price. Of course, it can always price just below at $c'' + g$ in which case there is no need to share rents with the intermediary. In that case, the cartel earns profit of $(c'' + g - c')D(c'' + g)$. We will begin by solving the cartel's optimal pricing problem assuming it will then successfully negotiate with the intermediary and then compare the associated profit with that from pricing just below the total unit cost of non-cartel supply.

Given it will achieve the NBS with the intermediary, the cartel's pricing problem is

$$\max_p (p - c' - s^*(p))D(p) = \alpha[\beta p - c' + (1 - \beta)(c'' + g)]D(p). \quad (13)$$

The first-order condition is

$$\alpha\beta D(p) + \alpha[\beta p - c' + (1 - \beta)(c'' + g)]D'(p) = 0. \quad (14)$$

So as to allow for the derivation of a closed-form solution, assume market demand is linear: $D(p) = a - bp$ where $a, b > 0$ and $a - b(c'' + g) > 0$. Solving the first-order condition for price yields

$$\begin{aligned} \hat{p} &= \left(\frac{1}{2b\alpha\beta}\right) [\alpha\beta a + b\alpha c' - b\alpha(1 - \beta)(c'' + g)] \\ &= \frac{a}{2b} + \frac{c'}{2\beta} - \left(\frac{1 - \beta}{2\beta}\right)(c'' + g). \end{aligned} \quad (15)$$

The intermediary's per unit payment is

$$\begin{aligned}
s^*(\hat{p}) &= (1 - \alpha\beta)\hat{p} - (1 - \alpha)c' - \alpha(1 - \beta)(c'' + g) \\
&= (1 - \alpha\beta) \left(\frac{a}{2b} + \frac{c'}{2\beta} - \left(\frac{1 - \beta}{2\beta} \right) (c'' + g) \right) - (1 - \alpha)c' - \alpha(1 - \beta)(c'' + g).
\end{aligned} \tag{16}$$

Finally, the cartel's profit is

$$(\hat{p} - c' - s(\hat{p}))D(\hat{p}) = \left(\frac{\alpha}{4b\beta} \right) [\beta a - bc' + b(1 - \beta)(c'' + g)]^2. \tag{17}$$

\hat{p} is the cartel's optimal price *when it anticipates coming to an agreement with the intermediary*. Interestingly, the optimal cartel price is *decreasing* in the cost of alternative supply. As $c'' + g$ rises, the payment to the intermediary $s^*(\hat{p})$ in (16) falls which means the cartel's marginal cost (production cost plus payment to the intermediary) declines which then causes it to lower its price. The cartel's optimal price is also decreasing in the bargaining power of the non-cartel supplier, β . When the intermediary has less bargaining power vis a vis the non-cartel supplier (that is, β is higher) then its threat point in bargaining with the cartel is reduced which lowers the payment that the cartel makes to the intermediary which reduces the cartel's marginal cost and thus its optimal price.

To determine when the cartel prefers to price at \hat{p} (and share rents with the intermediary) rather than price at $c'' + g$ (and forego cooperation with the intermediary), define Φ as the difference in the profit from these two alternatives:

$$\begin{aligned}
\Phi &\equiv \\
&\left(\frac{\alpha}{4b\beta} \right) [\beta a - bc' + b(1 - \beta)(c'' + g)]^2 - (c'' + g - c')[a - b(c'' + g)].
\end{aligned} \tag{18}$$

The cartel strictly prefers to price at \hat{p} if and only if $\Phi > 0$.

Relevant for deriving hypotheses for the ensuing empirical analysis, let us introduce a source of variation in firms' costs that will be a driver of the cartel's decision whether or not to share rents with the intermediary. For this purpose, let x denote some factor that influences the cost of the non-cartel supplier and may influence the cost of the cartel. Let us now denote the non-cartel's total unit cost (including the cost of the intermediary) to be $f(x)$ where $f: [0, \infty) \rightarrow [0, \infty)$ is an increasing continuously differentiable function, and the cartel's unit cost is denoted $h(x)$ where $h: [0, \infty) \rightarrow [0, \infty)$ is a continuously differentiable function. For example, suppose x captures the location of the buyer and a higher value means the buyer is closer to the cartel and farther away from the non-cartel firm. In that case, the cost of the non-cartel firm (cartel) is increasing (decreasing) in x : $f'(x) > 0 > h'(x)$. Consistent with this

example, it is assumed that the factor x has more of a positive impact on the non-cartel firm's cost than on the cartel's cost as described by the following condition: $(1 - \beta)f'(x) > h'(x)$. Finally, as the cartel has a cost advantage over the non-cartel supplier, $f(x) > h(x)$ for all $x > 0$ and, for purposes of the analysis, assume $f(0) = h(0)$ where $x \geq 0$.³¹

Substitute $f(x)$ for $c'' + g$ and $h(x)$ for c' in (15). Assuming the cartel chooses to price above the non-cartel firm's cost and come to an agreement with the intermediary, the cartel's optimal price is

$$\hat{p}(x) = \frac{a}{2b} + \frac{h(x)}{2\beta} - \left(\frac{1 - \beta}{2\beta}\right)f(x), \quad (19)$$

and price is decreasing in x :

$$\hat{p}'(x) = -\left(\frac{1}{2\beta}\right)[(1 - \beta)f'(x) - h'(x)] < 0. \quad (20)$$

Next substitute $f(x)$ for $c'' + g$ and $h(x)$ for c' in (18) so that

$$\Phi(x) \equiv \left(\frac{\alpha}{4b\beta}\right)[\beta a - bh(x) + b(1 - \beta)f(x)]^2 - (f(x) - h(x))[a - bf(x)]. \quad (21)$$

Our objective is to learn when $\Phi(x)$ is positive (and the cartel bribes the intermediary) and when it is negative (and it avoids dealing with the intermediary by undercutting the cost of the non-cartel supplier).

First note that if the cartel has no cost advantage then it prefers to work with the intermediary:

$$\Phi(0) = \left(\frac{\alpha\beta}{4b}\right)(a - bh(0))^2 > 0. \quad (22)$$

In this situation, the cartel earns zero profit by pricing at the cost of alternative supply and does better by pricing higher and providing a payment to the intermediary. When $x = 0$, $f(0) = h(0)$ (or $c' = c'' + g$) and \hat{p} is the monopoly price:

$$\hat{p}(0) = \frac{a}{2b} + \frac{h(0)}{2\beta} - \left(\frac{1 - \beta}{2\beta}\right)f(0) = \frac{a + bc'}{2b} = p^M(c'). \quad (23)$$

³¹ For example, if x is the buyer's location then this just says that there is some buyer with location x' whose location is close enough to the non-cartel supplier that the cost of the latter is the same as the cost of the cartel. Normalizing, we have $x' = 0$.

When the cartel has no cost advantage, it prices at the monopoly level – which obviously exceeds the cost of non-cartel supply – and prevents non-cartel supply by bribing the intermediary with a per unit payment of

$$\begin{aligned} s^*(\hat{p}(0)) &= (1 - \alpha\beta)\hat{p}(0) - (1 - \alpha)h(0) - \alpha(1 - \beta)f(0) \\ &= (1 - \alpha\beta)\left(\frac{a + bc'}{2b}\right) - (1 - \alpha)c' - \alpha(1 - \beta)c' = (1 - \alpha\beta)\left(\frac{a - bc'}{2b}\right). \end{aligned} \quad (24)$$

When the cartel has no cost advantage, it prefers to share rents with the intermediary. In the Appendix, it is shown that there exists a unique cost advantage defined by $x'' \in (0, x')$ such that the cartel sells through an intermediary (directly) if and only if $x < (>)x''$:

$$\Phi(x) \geq (\leq) 0 \text{ as } x \leq (\geq) x'', \text{ for } x \leq x'. \quad (25)$$

The cartel then optimally prices at $\hat{p}(x)$ when $x < x''$ and instead prices just below the cost of non-cartel supply when $x > x''$. This pricing strategy is depicted in Figure 5 for when $h'(x) = 0$, so that x only impacts the non-cartel firm's cost.³² If the cartel's cost advantage is sufficiently small (that is, $x < x''$) then the cartel prices at $\hat{p}(x)$ which exceeds the cost of non-cartel supply $f(x)$. In order to prevent that supply from coming onto the market, the cartel makes a per unit payment $s^*(\hat{p}(x))$ to the intermediary in exchange for it not providing its services to the non-cartel firm. The cartel then officially funnels the transaction through the intermediary with an invoice fee equal to $s^*(\hat{p}(x))$ per unit. As the cost advantage of the cartel rises (that is, x increases), the threat point of the intermediary declines and this translates into a lower per unit payment $s^*(\hat{p}(x))$. As a result, the cartel's optimal price declines. Due to bargaining, the cartel does not capture all of the possible gain associated with it having a bigger cost advantage. Thus, when the cost advantage is sufficiently large (that is, $x > x''$), the cartel chooses to forsake bribing the intermediary and instead prices below the cost of non-cartel supply. While this change in strategy involves a discrete drop in the collusive price (at $x = x''$), the cartel earns higher profit because it does not have to share any of the collusive rents with the intermediary. As the cartel does not involve the intermediary in the transaction, it engages in direct selling.

³² The figure is qualitatively similar when $h(x)$ is either increasing or decreasing as long as $(1 - \beta)f'(x) > h'(x)$.

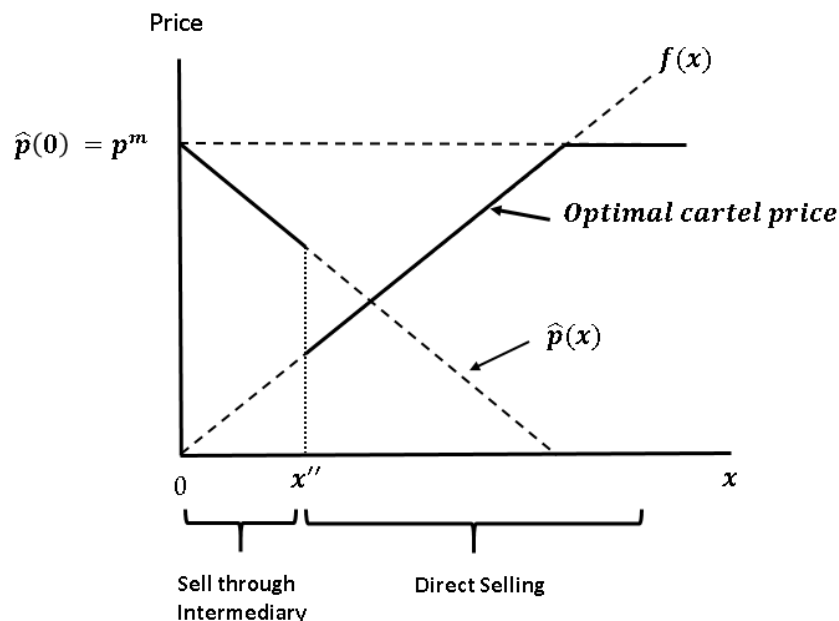


Figure 5: Cartel's Optimal Price

In the standard theory of collusive pricing in the presence of non-cartel suppliers, if the cost differential is small enough that the cost of non-cartel supply is less than the unconstrained joint profit-maximizing price then the overcharge (which is the difference between the collusive price and the market price in the absence of collusion) equals the cost differential because the cartel is constrained to pricing just below the cost of alternative supply. As $f(x)$ is the cost of non-cartel supply then this means the cartel prices at (or just below) $f(x)$. However, when the cartel can share profits with the intermediary (and the intermediary is essential for non-cartel supply), we find instead that the overcharge is the monopoly overcharge when the cartel has no cost advantage! While increasing its cost advantage lowers the overcharge, it is still above the standard overcharge until the cost advantage is sufficiently large. The ability of the cartel to share rents with the intermediary can increase the damages created by the cartel.

This section is concluded by deriving testable hypotheses from the theory. For this purpose, interpret x as the buyer's location where a higher value corresponds to the buyer being closer to a German cartel member and farther away from the nearest Eastern European non-cartel supplier. Thus, a higher value for x means higher transportation costs for the non-cartel firm and lower transportation costs for the cartel. As depicted in Figure 5, the theory predicts that when the buyer is sufficiently close to an Eastern European plant (that is, x is sufficiently low), the cartel member will sell through an intermediary and provide it with a

payment. When instead the buyer is sufficiently distant from the Eastern European plant (that is, x is sufficiently high), the cartel member will sell directly to the buyer. Thus, the more distant is the buyer from the nearest Eastern European plant, the more likely is it that the cartel member will engage in direct selling. This leads us to our first hypothesis.

Hypothesis 1: As a buyer's distance to the nearest Eastern European cement supplier rises, direct selling is more likely.

The above argument for selling through an intermediary is more likely to be operative, the more Eastern European capacity that could possibly be a source of non-cartel supply. Hence, the larger the share of Eastern European capacity controlled by the German cement cartel, the less of a need to bribe intermediaries which then makes it more likely to engage in direct selling.

Hypothesis 2: As the share of Eastern European capacity controlled by the German cement cartel rises, direct selling is more likely.

In the next section, these hypotheses are tested for the German cement cartel.

5. Empirical Analysis

In this section, we test these two hypotheses by estimating the likelihood that a customer, when buying from a German cement manufacturer, does so directly (“direct selling”) or through an intermediary. As the predictions pertain to when cement suppliers are cartelized and there are likely to be many behavioral changes between the cartel and post-cartel phases, the empirical analysis will focus on the time period during which firms were colluding. Section 5.1 describes the data set and offers some summary statistics on the use of intermediaries. Section 5.2 presents our econometric approach and estimation results.

5.1 Data Set and Descriptive Analysis

The raw data was collected by Cartel Damage Claims (CDC) of Brussels and consists of approximately 500,000 market transactions from 36 mostly large customers supplied by the German cement cartel from January 1993 to December 2005.³³ Market transactions include

³³ The data set used in this paper covers deliveries that account for about 4 percent of total sales in Germany. However, because the large cement producers are vertically integrated downstream (e.g., in the ready-mix

information on product types, dates of purchases, delivered quantities, involved intermediaries, cancellations, rebates, early payment discounts, and free-off charge deliveries as well as locations of the cement plants and unloading points. We have supplemented this raw data set with information on all cement plants located in Germany as well as those near the German border. Using Google Maps, all coordinates were retrieved for each unloading point in our sample and the number of independent cement suppliers located within a radius of 150 kilometers (road distance) of those coordinates serves as a measure of the set of available suppliers to a customer. Additionally, we calculated the road distance to the nearest East European plant and added data about regional construction activity from the German Statistical Office to capture demand fluctuations.

The empirical analysis uses data on sales from plants located in Germany and for one specific cement type called ‘CEM I’ (Standard Portland Cement) which accounts for almost 80 percent of all available transactions.³⁴ For reasons of consistency and interpretation, the transaction data is aggregated on a monthly basis at the level of the cement plant-cement seller-unloading point-cement consistency (32.5, 42.5 and 52.5 N/R). Table 1 presents the (quantity weighted) descriptive statistics of the data set.

As the theoretical predictions pertain to when firms are colluding, the empirical analysis will be based on the 23,659 observations during the cartel period which runs from the start of the data set in January 1993 to the collapse of the cartel in February 2002.³⁵ While we could include the post-cartel data and explore how the correlates with the use of intermediaries changed, we are concerned that the transition from collusion to competition involved an extensive restructuring of buyer-seller relationships which would make such an analysis problematic.

Customers in our data set are, on the whole, large. *Customer size* is defined to be the quantity of cement purchased per year from all suppliers. When weighing each customer by

concrete industry), the share of the data set from the non-integrated segment of the market is substantially larger than 4%. Given that Hortaçsu and Syverson (2007) find little evidence that vertical foreclosure effects are quantitatively important in the U.S. cement and concrete industries, it is reasonable to assume that the observed prices in our dataset are similar to prices overall.

³⁴ The share of pure CEM I cement is decreasing towards the end of the data set as cement companies began to partially substitute raw cement (“clinker”) with other materials such as sand or ash in order to reduce carbon dioxide emissions.

³⁵ For an analysis of the cartel collapse, see Harrington et al (2015).

its share of the number of transactions, average customer size is about 110,000 tons per year which is reported in Table 1. If instead each customer is counted only once, average customer size is 30,080 tons per year with a standard deviation of 53,580 tons.

Table 1: Descriptive Statistics (quantity weighted)

	Cartel period		Post Cartel Period		Overall	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Direct selling	0.43	(0.50)	0.74	(0.44)	0.50	(0.50)
Selling through intermediary	0.57	(0.50)	0.26	(0.44)	0.50	(0.50)
Customer size (million tons /year)	0.09	(0.10)	0.16	(0.18)	0.11	(0.12)
Next East European Plant (in 1000km)	0.40	(0.16)	0.39	(0.17)	0.40	(0.16)
GCCEP (in %)	0.70	(0.27)	0.98	(0.00)	0.76	(0.26)
GCCE (in %)	0.59	(0.18)	0.77	(0.01)	0.63	(0.17)
No. of firms within 150km, yearly count	5.17	(2.73)	4.69	(2.28)	5.06	(2.64)
Unload region: East	0.26	(0.44)	0.29	(0.45)	0.26	(0.44)
Unload region: West	0.32	(0.47)	0.27	(0.45)	0.31	(0.46)
Unload region: North	0.10	(0.29)	0.06	(0.24)	0.09	(0.28)
Unload region: South	0.33	(0.47)	0.37	(0.48)	0.34	(0.47)
Construction employment	0.86	(0.23)	0.72	(0.19)	0.83	(0.23)
Construction permits	0.15	(0.06)	0.09	(0.04)	0.13	(0.06)
Consistency 32.5	0.31	(0.46)	0.40	(0.49)	0.33	(0.47)
Consistency 42.5	0.65	(0.48)	0.52	(0.50)	0.62	(0.49)
Consistency 52.5	0.04	(0.20)	0.08	(0.27)	0.05	(0.22)
Post Cartel period	0.00	(0.00)	1.00	(0.00)	0.23	(0.42)
Observations	23659		6008		29667	

Notes: GCCE and GCCEP are the (yearly) shares of capacity controlled by cartel firms. GCCE is the German Cartel Capacity in Eastern Europe while GCCEP is the German Cartel Capacity in Eastern Europe plus Polish Cartel Capacity. Construction employment is the yearly number of construction workers (in millions) per cartel region; Construction permits is the yearly number of permits (in millions) for residential and non-residential apartments in houses per cartel region.

The average road distance from a buyer's unloading point to the nearest Eastern European plant is around 400 km. By the theory, the variable of interest is a buyer's best alternative supplier in Eastern Europe which may not be the nearest Eastern Europe plant because that plant may not have the lowest total cost (due to higher production cost), may not have available capacity, or may be controlled by the German cement cartel. While not perfect, *nearest Eastern European plant* would seem to be a good proxy for a buyer's best source of supply outside of the cartel.

German cartelized capacity in Eastern European (GCCE) is the share of all capacities in the Czech Republic, Poland, and Slovakia owned by the German cement cartel. Over the entire cartel period, this share averaged 59 percent though, we know from Figure 1, it steadily rose until it reached 77 percent by the end of the cartel and remained there. Thus, eventually, at most 23 percent of capacity was a source of non-cartel supply. It was previously mentioned that the Polish cement cartel may have agreed not to import cement into Germany. This would

have started as early as 1998 when the Polish cement cartel was formed. For that reason, Table 2 also reports *German cartelized capacity in Eastern European plus Polish cartelized capacity (GCCEP)* which is the share of all capacities in the Czech Republic, Poland, and Slovakia owned by members of the German and Polish cement cartels. It averaged 70 percent and reached a peak of 98 percent by the cartel’s end. Results will be presented using *GCCE* though are very similar when using *GCCEP*.

Turning to the remaining independent variables, the *number of firms within 150km* of a buyer measures potential competition if firms were competing. Though there are fewer transactions in the north for the customers in our data set, transactions are almost equally distributed across the other three regions. The two demand-side variables are *construction employment* and *construction permits*.

The dependent variable is an indicator variable that takes the value 1 when the transaction occurred through direct selling and 0 when it involved an intermediary. Under *direct selling*, prices are directly negotiated between the buyer and the cement producer and the latter files the invoice. Whenever the party which filed the invoice was not a cement producer, we categorized the distribution channel as *intermediary*. The fraction of transactions with direct selling was 43 percent when the cartel was operating which is significantly less than the 74 percent after the cartel breakdown.

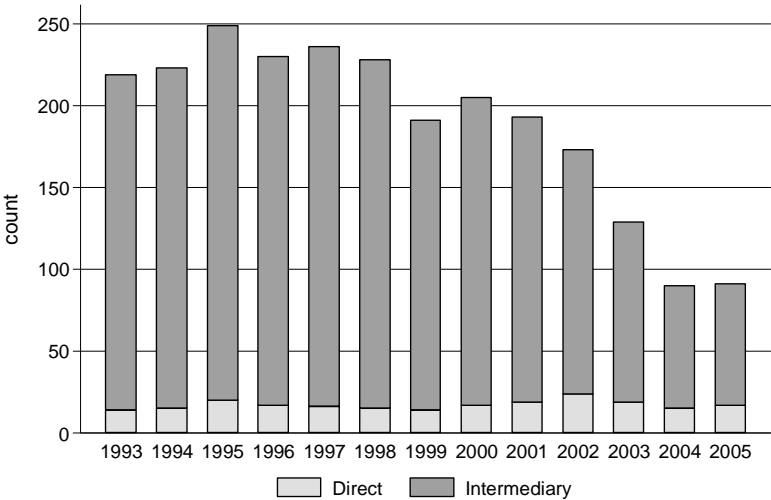


Figure 6: Number of Representatives of Distribution Channels, 1993-2005
Data Source: own analysis based on CDC data; unweighted averages

Figure 6 reports the total number of distinct agents involved in at least one transaction and are broken down according to the two distribution channels. The transactions involved many

more intermediaries than direct selling agents (who must manufacture cement). Note that the number of intermediaries started to decline during the cartel period and this reduction greatly accelerated after the cartel breakdown. While the early years of the cartel regularly saw more than 200 different intermediaries involved in the transactions of the 36 customers in our data set, their number dropped below 75 in the post-cartel period.³⁶

Consistent with the claim that the cartel was seeking to control intermediaries in order to reduce imports, the 2009 Judgment of the Higher Regional Court provides documentary evidence that members of the German cement cartel acquired some intermediaries who were acting as importers and the import activities of certain intermediaries and buyers.³⁷ Although such acquisitions would have reduced import activities to some extent, it would have been too costly to apply it to a large fraction of all intermediaries that were in principle able to engage in import activities.³⁸ This observation leads to the complementary strategy of sharing rents with intermediaries in exchange for them not importing non-cartel supply into the German cement market.

5.2 Empirical Analysis and Results

We now turn to providing an econometric model to test the hypotheses put forth at the end of Section 3. Using a logit model, the dependent value in our model takes the value 1 if the transaction was done through direct selling and 0 otherwise.

$$y^* = \beta'X + \varepsilon, \quad y = 1 \text{ if } y^* > 0, \quad y = 0 \text{ otherwise}$$

The dependent variable y is specific to the identity of the customer's unloading point, the seller (which is either a cement manufacturer or an intermediary), the delivering plant, and time. Vector X includes several variables that were also used in Harrington et al. (2015). A customer's size is measured by the total annual ordered quantity. A customer's market environment is measured by the number of cement firms within 150 km road distance. Properties of the delivered products are two indicator variables for the consistency of the

³⁶ As we are focusing on the 36 customers in our data set, the observed reduction in the number of intermediaries does not necessarily mean they exited the market but only that their services were no longer used by those 36 customers.

³⁷ Examples explicitly mentioned were the incidents referred to as "Berger", "Consulta", "Meier", and "Lueg & Duda" (paragraphs 41ff.).

³⁸ This is especially true in light of the large number of construction material suppliers who could act as intermediaries.

cement. As there may be unobserved heterogeneity between regions, region-fixed effects are included. Demand proxies include the number of construction workers and the number of new construction permits, both of which are measured for the region of a customers' unloading point. In light of our hypotheses, the key variables are the distance to the nearest Eastern European plant and the share of Eastern European capacity controlled by the members of the German cement cartel. By "Eastern Europe," we mean the Czech Republic, Poland, and Slovakia which, as argued earlier, were the overwhelming sources of non-cartel supply.

Table 2: Logit estimation – Coefficients

	(1)	(2)
Customer size	0.463	(0.40)
No. of firms within 150km	-0.152**	(-2.49)
East	3.993***	(7.01)
South	3.043***	(6.86)
North	-3.147***	(-3.36)
Consistency 32.5	-0.217	(-0.93)
Consistency 52.5	1.504***	(3.18)
Construction employment	\	(-2.33)
Construction permits	-4.303**	(-2.07)
Distance next EE plant	3.731***	(2.61)
GCCE	1.364**	(2.51)
GCCE*Dist.next EE plant		
Constant	-2.013	(-1.60)
N	23659	23659
Pseudo R ²	0.22	0.23

t statistics in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, Standard errors were clustered.

Using maximum likelihood, Table 2 reports the estimated coefficients for two specifications. Our hypotheses are that the estimated coefficients on *GCCE* and *Distance* are positive so that direct selling is more likely (or, equivalently, using an intermediary is less likely) when the German cement cartel owns more Eastern European capacity and the distance between the buyer and the nearest Eastern European plant is greater. Specification (2) differs from that of (1) in allowing for an interaction between *GCCE* and *Distance*. The estimated coefficient on that variable is predicted to be negative because *Distance* should matter less if there is less non-cartel capacity. The corresponding average marginal effects are in Table 3.

In Table 3, the distance to the nearest Eastern European plant is positively related to the likelihood of a customer buying directly.³⁹ This finding is consistent with Hypothesis 1. As the variable is measured in 1000 kilometers, an increase in distance of 250 kilometers between a customer and the nearest plant in Eastern Europe raises the probability of direct selling by around 13-14 percent. It is then less likely that a transaction is conducted through an intermediary if the cost advantage of the cartel supplier vis-à-vis the non-cartel-supplier is enhanced, which is in line with the prediction of the theoretical model.

Table 3: Logit estimation results - Average marginal effects

	(1)		(2)	
Customer size	0.069	(0.41)	-0.007	(-0.04)
No. of firms within 150km	-0.023**	(-2.44)	-0.022**	(-2.40)
East	0.646***	(14.45)	0.621***	(12.28)
South	0.415***	(9.30)	0.395***	(8.31)
North	-0.259***	(-7.92)	-0.250***	(-6.69)
Consistency 32.5	-0.032	(-0.93)	-0.026	(-0.75)
Consistency 52.5	0.261***	(2.98)	0.255***	(2.94)
Construction employment	-0.313**	(-2.30)	-0.178	(-1.29)
Construction permits	-0.642**	(-2.01)	-0.787**	(-2.57)
Distance next EE plant	0.556***	(2.73)	0.518**	(2.54)
GCCE	0.203***	(2.62)	0.194***	(2.78)
Distance GCCE=0			0.924***	(3.18)
Distance GCCE=1			0.113	(0.39)
N	23659		23659	
Pseudo R ²	0.22		0.23	

Average marginal effects. Standard Errors were clustered. *t* statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Our estimates also support Hypothesis 2. The probability of direct selling is higher when the share of Eastern European production capacity controlled by the German cement cartel rises. The probability of direct selling is increased by 19-20 percent when German control over Eastern European capacity is increased from zero to 100 percent. This finding is consistent with the argument that the cartel's need to share rents with intermediaries is diminished when the cartel controls more of the capacity that could produce imports.

Even stronger evidence in support of rent sharing with intermediaries sharing comes from the interaction term. In specification (2), the marginal impact of distance on the probability of direct selling is weaker when the cartel controls more Eastern European capacity. Thus, the predicted negative relationship between distance and direct selling due to the need to bribe

³⁹ For each observation, we calculate the effect of an arbitrarily small change in distance on direct selling and take the average of these effects over the whole sample.

intermediaries is reduced in magnitude when there is less non-cartel supply. When the German cement cartel does not control any of the Eastern European capacity ($GCCE = 0$), the average marginal effect of distance is .924 so that a rise in distance of 250 kilometers raises the probability of direct selling by 23 percent. However, if the German cement cartel controls all of the Eastern European capacity ($GCCE = 1$), the average marginal effect of distance is far smaller at 0.113 and is no longer statistically significant. Absent the need to bribe intermediaries, the distance between a customer and the nearest Eastern European plant should not influence whether a customer that buys its cement from a German plant uses an intermediary, and that is supported by the data.

6. Conclusion

It is fair to say that the German cement manufacturers ran an effective cartel as reflected in an average overcharge exceeding 25 percent (Hüschelrath, Müller, and Veith, forthcoming) and a duration exceeding a decade. Though the cartel eventually collapsed due to the lack of compliance of one of its members, it *was* able to constrain external sources of instability. The cartel's members purchased numerous cement plants in Eastern Europe that were a potential source of low-priced imports. But even before those acquisitions, our analysis provided evidence that the cartel limited imports by sharing rents with German intermediaries so that they would not source foreign supply. This bribery scheme was executed by allowing an intermediary to issue an invoice and charge a fee on a transaction between a German cement cartel member and a German cement customer even though the cement was transported directly from the seller to the buyer. The sharing of rents with intermediaries was predicted to be more likely when the threat of non-cartel supply was more serious. Consistent with that prediction, we showed that the closer was the distance between a German cement buyer and the nearest Eastern European cement plant, the more likely that a German cement cartel member was to involve an intermediary in selling to that buyer. Furthermore, this effect was found to be weaker when the German cement cartel controlled more Eastern European capacity in which case there was less of a need to bribe intermediaries. This episode is yet more evidence of the creativity and audacity of cartels to control sources of instability in order to be able to maintain supracompetitive prices.

Appendix

Let us show that there exists a unique $x'' \in (0, x')$ such that (25) is true. Consider the effect of raising the factor x (so that the cartel has a cost advantage):

$$\begin{aligned} \Phi'(x) = & \left(\frac{\alpha}{2\beta}\right) [\beta a - bh(x) + b(1 - \beta)f(x)][(1 - \beta)f'(x) - h'(x)] \\ & - (f'(x) - h'(x))[a - bf(x)] + b(f(x) - h(x))f'(x) \end{aligned} \quad (26)$$

Evaluate this derivative at $x = 0$,

$$\begin{aligned} \Phi'(0) = & \left(\frac{\alpha}{2\beta}\right) [\beta a - b\beta f(0)][(1 - \beta)f'(0) - h'(0)] \\ & - (f'(0) - h'(0))[a - bf(0)] \end{aligned} \quad (27)$$

$$= -[a - bf(0)] \left[\left(\frac{\alpha\beta}{2}\right) f'(0) + \left(\frac{2-\alpha}{2}\right) (f'(0) - h'(0)) \right] < 0$$

because $f'(0) - h'(0) \geq 0$ follows from assuming $(1 - \beta)f'(x) > h'(x)$. In sum, when the cartel does not have a cost advantage, $\Phi(0) > 0$ (so the cartel prefers to price above the non-cartel firm's cost at \hat{p} and provide a payment to the intermediary) and $\Phi'(0) < 0$ (so that the incremental profit from the option of sharing rents with the intermediary is decreasing in x where recall that a higher x corresponds to a greater cost advantage for the cartel).

Next let us derive sufficient conditions for there to exist $x' > 0$ such that $\Phi(x') < 0$ so the cartel prefers to undercut the non-cartel firm's cost. Given $\hat{p}(0) > f(0)$, $\hat{p}(x)$ is decreasing in x , and $f(x)$ is increasing in x , there exists $x' > 0$ such that $\hat{p}(x') = f(x')$:

$$\frac{a}{2b} + \frac{h(x')}{2\beta} - \left(\frac{1 - \beta}{2\beta}\right) f(x') = f(x') \rightarrow f(x') = \frac{\beta a + bh(x')}{b(1 + \beta)}. \quad (28)$$

We then have:

$$\hat{p}(x) > f(x) \text{ for all } x \in [0, x'). \quad (29)$$

Evaluate Φ at $x = x'$:

$$\begin{aligned} \Phi(x') = & \left(\frac{\alpha}{4b\beta}\right) [\beta a - bh(x') + b(1 - \beta)f(x')]^2 - (f(x') - h(x'))[a \\ & - bf(x')] \end{aligned} \quad (30)$$

$$= \left(\frac{\alpha}{4b\beta}\right) \left[\beta a - bh(x') + b(1 - \beta) \left(\frac{\beta a + bh(x')}{b(1 + \beta)} \right) \right]^2$$

$$-\left(\frac{\beta a + bh(x')}{b(1 + \beta)} - h(x')\right) \left[a - b \left(\frac{\beta a + bh(x')}{b(1 + \beta)} \right) \right]$$

$$\Phi(x') = - \left[\frac{(1 - \alpha)\beta}{b(1 + \beta)^2} \right] (a - bh(x'))^2 < 0.$$

Next take the second derivative of Φ :

$$\begin{aligned} \Phi''(x) &= \left(\frac{\alpha}{2\beta}\right) [\beta a - bh(x) + b(1 - \beta)f(x)][(1 - \beta)f''(x) - h''(x)] \\ &\quad + \left(\frac{\alpha b}{2\beta}\right) [(1 - \beta)f'(x) - h'(x)]^2 - (f''(x) - h''(x))[a - bf(x)] \\ &\quad + b(f'(x) - h'(x))f'(x) + b(f'(x) - h'(x))f'(x) \\ &\quad + b(f(x) - h(x))f''(x). \end{aligned} \tag{31}$$

We will assume $\Phi'' > 0$. Sufficient conditions for that to be the case are f and h are linear:

$$\Phi''(x) = \left(\frac{\alpha b}{2\beta}\right) [(1 - \beta)f'(x) - h'(x)]^2 + 2b(f'(x) - h'(x))f'(x) > 0, \tag{32}$$

noting that previous assumptions make these two terms positive. As $\Phi(0) > 0 > \Phi(x')$ then, given Φ is convex, it follows that there exists a unique $x'' \in (0, x')$ such that (25) is true.

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